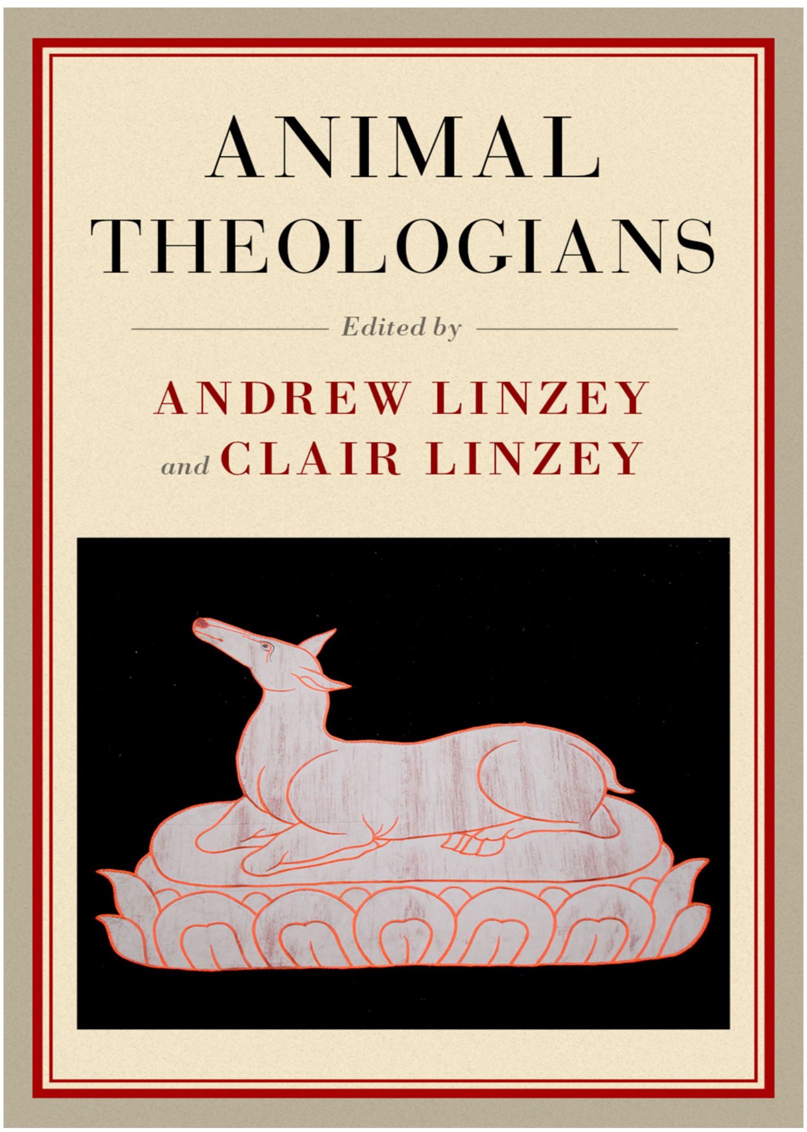
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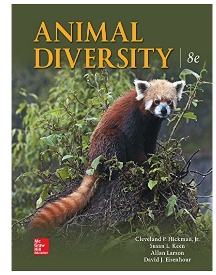

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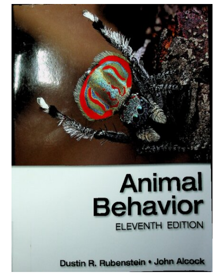

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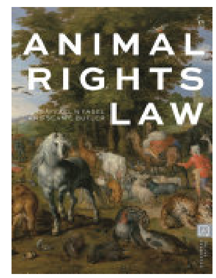

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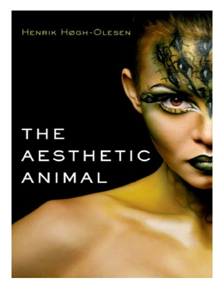

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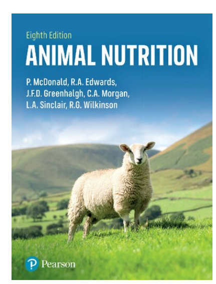

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An Ethical Critique of Fur Factory Farming

This book is dedicated to Julius Kristoff Ormiston
for his faith, generosity, and love for animals

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Introduction

Before *Animal Theology*

Andrew Linzey and Clair Linzey

Defining Theology

Karl Barth famously described theology as "a *logia*, logic, or language bound to *the theos*, which makes it possible and also determines it."[1]

> We are speaking here of the God of the Gospel, his work and action, and of the Gospel in which his work and action are at the same time his speech. This is his Word, the Logos in which the theological *logia*, logic, and language have their creative basis and life.[2]

This is, of course, a Christian definition of theology, since the "Word" in question is the incarnate Logos, the Christ, who is the center of all Christian theology. But despite offering a specifically Christian definition of theology, Barth provides a useful starting point for understanding theology in a broader sense. The key is in the word "logia," which Barth describes as the "logic" of theology itself.

From this wider perspective, we may define theology as an understanding of the inner logic of a faith position. Theology in this sense must be sharply distinguished from knowledge of religion per se or the study of religion itself. Regrettably, many university departments of theology have now changed their names, to become departments of religion or religious studies, or have supplemented the word "theology" with one of these other appellations (including,

sadly, what is now the Faculty of Theology and Religion at the University of Oxford). But there is a difference between *knowing about* and *understanding of*. The psychology, the sociology, the philosophy, and the history of religion are all excellent fields of study and can be useful adjuncts to study of theology. They can illuminate theological positions and help us to contextualize them. But they are not theology. And neither do they by themselves fulfill the aim of theology, which is an understanding of its inner logic. There can be Jewish, Muslim, Hindu, and Christian theologies (to name but a few), but the aim should always be the same—not just to know about the faith position, but to grasp the inner logia of it.

Even this is not entirely satisfactory. Faith is often contrasted with reason or evidence, whereas in fact there are few religious positions devoid of both. Moreover, there is an unfortunate tendency to define faith as a private affair (like personal likes and dislikes) wholly or largely unrelated to society as a whole. Indeed, some have seen the attempt to define religion as faith as a way of marginalizing religion in contemporary society.[3] Perhaps, then, it is best to define theology as an understanding of the inner logic of a religious or spiritual stance or position.

But we need to go further. Religious perspectives are not just a set of intellectual propositions to which believers may give assent. Of course, religious perspectives invariably consist of intellectual positions, sometimes of a very complicated kind, and it is certainly important to have an appreciation of a religion's ideas and official statements, including its normative scriptures that enable us to have some insight into what a tradition holds to be true. But that is not all that is required to understand a religious perspective. Theology requires as much an understanding of the rites, symbols, and practices of what are (in most cases) living religions as it does an understanding of their intellectual affirmations. That is why we need to go further and speak of an understanding of the inner *moral* theo-logic that encompasses the values of the perspectives themselves. Indeed, so vital is the ethical dimension of religious belief that we might define all theology as moral theology, in the sense that it is

lived theology with implicit and explicit moral values.[4] The mind we need here is not that of an anthropologist who seeks to be a neutral observer (if there can be such a thing) of people, events, and phenomena, but rather that of an open participant who treats religious practices seriously and seeks to grasp their inner logia.

When at least 85 percent of the world's population is religious, understanding how people believe, practice, and live within religious traditions is a tremendously important goal if we want genuine intercultural and interfaith dialogue. It is difficult to see how there can be any possibility of overcoming conflict and mutual antagonisms, and establishing enduring mutuality without that understanding. Theology, then, as we see it, is a much more demanding undertaking and far more important than is commonly supposed. It does not of itself require a religious belief (as many have previously supposed), but it does require people who can think beyond familiar boundaries and be open to insight into new layers of meaning and value in the world.

It is important to distinguish between understanding and agreement. Intellectual understanding is not the same as intellectual assent—almost the opposite. The deeper the understanding, the deeper the ability to see how the tradition can be developed and improved. John Macquarrie famously described theology as the attempt to think through the Church's faith into a coherent whole.[5] While this book is not limited to the specifically Christian approach that Macquarrie takes, the word "coherent"[6] is relevant. One idea or practice must relate to another, and there needs to be inner intellectual coherence in doctrine and ethics. Not everything that has accrued within a tradition is necessarily essential to the main beliefs of that tradition. This means that theology is necessarily a critical discourse requiring understanding, engagement, and also the fullest use of one's critical faculties. The inner logic must not be shortchanged or unexamined.

Exploring the Variety of Random Documents with Different Content

better not to use the expression pseudo-parasites for incidental parasites, but to keep to the original meaning, for it is not at all certain that pseudo-parasites are not described, even nowadays.

The Influence of Parasites on the Host.—In a great many cases, we are not in a position to state anything regarding any marked influence exercised by the parasite on the organism, and on the conditions of life, of the host. Most animals and many persons exhibit few signs of such influence, an exception being infestation with helminthes and certain other parasites which produce eosinophilia in the blood. As a general rule, the parasite, which is always smaller and weaker than its host, does not attempt to endanger the life of the latter, as simultaneously its own existence would be threatened. The parasite, of course, robs its host, but usually in a scanty and sparing manner, and the injuries it inflicts can hardly be taken into account. There are, however, numerous cases[4] in which the situation of the parasites or the nature of their food, added to their number and movements, may cause more or less injury, and even threaten the life of the host. It stands to reason that a *Cysticercus cellulosæ* situated in the skin is of but slight importance, whereas one that has penetrated the eye or the brain must give rise to serious disorders. A cuticular or intestinal parasite is, as a rule, less harmful than a blood parasite. A helminth, such as an *Ascaris lumbricoides* or a tapeworm, that feeds on the residues of foodstuffs within the intestine, will hardly affect its host by depriving it of this material. The case is different when the parasites are very numerous, especially when the heavily infested host happens to be a young individual needing all it ingests for its own requirements, and therefore unable to sustain the drain of numerous intruders in the intestine. Disturbances also set in more rapidly when the intestinal helminthes are blood-suckers, the injury to the host resulting from the kind of food taken by the parasite.

Generally, the disorders caused by loss of chyle are insignificant when compared with those induced by the GROWTH and agglomeration of the helminthes. The latter may cause chiefly obstructions of small vessels or symptoms of pressure in affected or contiguous organs, with all those complications which may arise secondarily, or they may even lead to the complete obliteration of the organ invaded. Of course the symptoms will vary according to the nature of the organ attacked.

In consequence also of the MOVEMENTS of the parasites, disorders are set up that may tend to serious pathological changes of the affected organs. The collective migrations, undertaken chiefly by the embryos of certain parasites (as in trichinosis, acute cestode tuberculosis), are still more harmful, as are also the unusual migrations of other parasites, which, incidentally, may lead to the formation of so-called worm abscesses or to abnormal communications (fistulæ) between organs that are contiguous but possess no direct connection.

Recently, several authors have called attention to the fact that the helminthes produce substances that are TOXIC to their host; and the effects of such poisons explain the pathology of helminthiasis far more satisfactorily than the theory of reflex action.

In a number of cases these toxic materials (leucomaines) have been isolated and their effects on living organisms demonstrated by actual experiments. It also appears that the absorption of materials formed by the decomposition of dead helminthes may likewise cause toxic effects. However, our knowledge of these conditions is as yet in its initial stage.[5]

Nearly all the symptoms caused directly or indirectly by parasites are of such a nature that the presence of the parasites cannot be diagnosed with any certainty, or only very rarely. The most that can be done is to deduce the presence of parasites by the exclusion of other causes. Fortunately, however, there are sufficient means by

which we may confirm the diagnosis in a great many cases. Such means consist not only in a minute examination of the patient by palpation, percussion and local inspection, but also in the microscopical examination of the natural secretions and excretions of the body, such as sputum, nasal mucus, urine and fæces. Though such examinations may entail loss of time, they are necessary in the interest of the patient. It appears, moreover, that quackery, which has gained considerable ground even in the treatment of the helminthic diseases of man, can thus be considerably limited.

Origin of Parasites.[6]—In former times, when the only correct views that existed related to the origin of the higher animals, the mode of multiplication of parasites as well as of other lowly animals was ascribed to SPONTANEOUS GENERATION (*generatio æquivoca*), and this opinion prevailed throughout the middle ages. The writers on natural science merely devoted their time to the interpretation of the views of the old authors, and perpetuated the opinions of the ancients on questions, which, even in those days, could have been correctly explained merely by observation.

It was only when observations were again recommenced, and the microscope was invented, that the idea of spontaneous generation became limited. Not only did the microscope reveal the organs of generation or their products (eggs) in numerous animals, but Redi succeeded in proving that the so-called *Helcophagi* (flesh maggots) are only the progeny of flies, and never appear in the flesh of slaughtered animals when fully developed flies are prevented from approaching and depositing their eggs on it. Swammerdam likewise knew that the "worms" living in the caterpillars of butterflies were the larvæ of other insects (ichneumon flies) which had laid their eggs in their bodies; he also discovered the ova of lice. The two authors mentioned were, however, unwilling to see that the experience they had gained regarding insects applied to the helminthes. Leeuwenhoek also vehemently opposed the theory of a

spontaneous generation, maintaining that, on a basis of common-sense, eggs, or at all events germs, must exist, even though they could not be seen.

The use of the microscope also revealed a large number of very small organisms in the water and moist soil, some of which undoubtedly resembled helminthes. Considering the wide dissemination of these minute organisms, it was natural to conjecture that after their almost unavoidable introduction into the human system they should grow into helminthes (Boerhave, Hoffmann). Linnæus went even further, for he traced the descent of the liver-fluke of sheep from a free-living planaria (*Dendrocœlum lacteum*), the *Oxyuris vermicularis* from free-living nematodes, and the *Tænia lata* (*i.e.*, *Dibothriocephalus latus*) from a tapeworm (*Schistocephalus solidus*) found free in the water. Linnæus' statements met with general approval. However, we must bear in mind that at that time the number of helminthes known was very small, and many of the forms that we have long ago learned to differentiate as specific were then regarded as belonging to one species. Linnæus' statements were partly supported by similar discoveries by other investigators, such as Unzer, and partly also by the discovery of eggs in many helminthes. It was believed that the eggs hatched in the outside world gave rise to free-living creatures, and that these, after their introduction into the intestine, were transformed into helminthes. By means of these eggs the old investigators tried to explain the HEREDITARY TRANSMISSION of the intestinal worms, which was universally believed until the commencement of the last century. Some authors went so far as to regard the intestinal worms as congenital or inherited; they maintained the possibility of direct transmission, as in suckling, and denied that the eggs reaching the external world had anything to do with the propagation of the parasites.

The more minute comparison between the supposed free-living stages of the helminthes and their adult forms, and the impossibility of finding corresponding free forms for the ever-increasing number of parasitic species, revealed the improbability of Linnæus' statements (O. Fr. Müller). It was the latter author also who recognized the origin of the tapeworms (*Schistocephalus, Ligula*) found free in the water. They originate from fishes which they quit spontaneously.

However, in spite of the fact that van Doeveren and Pallas correctly recognized the significance of the eggs in the transmission of intestinal worms, these statements remained disregarded, as did Abildgaard's observation, experimentally confirmed, that the (immature) cestodes from the abdominal cavity of sticklebacks became mature in the intestines of aquatic birds. Moreover, at the end of the eighteenth and the commencement of the nineteenth centuries, after helminthology had been raised to a special branch of study by the successful results of the investigations of numerous authors (Goeze, Bloch, Pallas, Müller, Batsch, Rudolphi, Bremser), many of whom experienced a "divine joy" in searching the intestines of animals for helminthes, some authors reverted to *generatio æquivoca*, without, however, entirely denying the existence of organs of generation and eggs. The fact that a few nematodes bore living progeny—a fact of which Goeze was already aware—had no influence on the erroneous opinion, as in such cases it was considered that the young continued to develop beside the old forms. There were also many helminthes known that never developed sexual organs and never produced eggs, and which therefore were referred to *generatio æquivoca*. People were convinced that the intestinal mucous membrane or an intestinal villus could transform itself into a worm, either in a general morbid condition of the body, or in pathological changes of a more local

character. The appearance of helminthes was even regarded as useful and as a means for the expulsion of injurious matter.

These views, firmly rooted and supported by such eminent authorities as Rudolphi and Bremser, could not easily be overthrown. First, a change took place in the knowledge of the trematodes. In 1773, O. Fr. Müller discovered *Cercariæ* living free in water. He regarded them as independent creatures and gave them the name that is still used at the present time. Nitzsch, who also minutely studied these organisms and who recognized the resemblance of the anterior part of their bodies to a *Fasciola*, did not, however, arrive at a correct conclusion. He regarded the combination rather as that of a *Fasciola* with a *Vibrio*, for which he mistook the characteristic tail of the cercaria. He also noticed the encystment (transformation into the "pupa") on foreign bodies of many species of these animals, but was of opinion that this process signified only the termination of life.

Considerable attention was attracted to the matter when Bojanus first published a paper entitled "A Short Note on Cercaria and their Place of Origin." He pointed out that the cercariæ creep out of the "royal yellow worms," which occur in freshwater snails (*Limnæa, Paludina*), and are probably generated in these worms.

Oken, in whose journal, *Isis* (1818, p. 729), Bojanus published his discovery, remarks in an annotation, "One might lay a wager that these Cercariæ are the embryos of Distomes." Soon after (1827), C. E. v. Baer was able to confirm Bojanus' hypothesis that the cercariæ as a "heterogeneous brood" originated from spores in parasitic tubes in snails (germinating tubes). Moreover, Mehlis (*Isis*, 1831, p. 190) not only discovered the opercula of the ova of *Distoma*, but likewise saw the infusorian-like embryo emerge from the eggs of *Typhlocœlum* (*Monostomum*) *flavum* and *Cathæmasia* (*Distoma*) *hians*. A few years later (1835) v. Siebold observed the embryos (miracidia) of the *Cyclocœlum* (*Monostomum*) *mutabile*, and discovered in their interior a cylindrical body that behaved like

an independent being ("necessary parasite"), and was so similar in appearance to the "royal yellow worms" (Bojanus) that Siebold considered the origin of the latter from the embryos of trematodes as, at all events, possible. Meanwhile, v. Nordmann of Helsingfors had in 1832 seen the miracidia of flukes provided with eyes swimming in water; v. Siebold (1835) had observed the embryos, or oncospheres, of tapeworms furnished with six hooklets in the so-called eggs of the Tænia; while Creplin (1837) had discovered the "infusorial" young of the *Diphyllobothrium* (*Bothriocephalus*) *ditremum*, and conjectured that similar embryos were to be found in other cestodes with operculated eggs. At all events, the fact was established that the progeny of the helminthes appeared in various forms and was partly free living. The researches of Eschricht (1841) were likewise of influence, as they elucidated the structure of the Bothriocephali, and proved that the encysted and sexless helminthes were merely immature stages.

J. I. Steenstrup (1842) was, however, the first to furnish explanations for the numerous isolated and uncomprehended discoveries. Commencing with the remarkable development of the Cœlenterata, he established the fact that the Helminthes, especially the endoparasitic trematodes, multiply by means of alternating and differently formed generations. Just as the polyp originating from the egg of a medusa represents a generation of medusæ, so does the germinal tube ("royal yellow worm") originating from the ciliated embryo of a Distoma, etc., represent the cercaria. These were consequently regarded as the progeny of trematodes, and Steenstrup, guided by his observations, conjectured that the cercaria, whose entrance into the snails he had observed accompanied by the simultaneous loss of the propelling tail, finally penetrated into other animals, in which they became flukes.

Part of this hypothetical cycle of development was erroneous, and in other particulars positive observation was lacking, but the path

pursued was in the right direction. Immediately after the appearance of Steenstrup's celebrated work, v. Siebold expressed his opinion that the encapsuled flukes certainly had to travel, *i.e.*, to be transmitted with their bearers into other hosts, before becoming mature. This view was experimentally confirmed by de Filippi, La Valette St. George (1855), as well as by Pagenstecher (1857), while the metamorphosis of the ciliated embryo of Distoma into a germinal tube was first seen by G. Wagener (1857) in *Gorgodera* (*Distoma*) *cygnoides* of frogs. All that we have subsequently learned from the works of numerous investigators about the development of endoparasitic trematodes has certainly increased our knowledge in various directions, and, apart from the deviating development of the *Holostomidæ* has, as a whole, confirmed the briefly sketched cycle of development.

Steenstrup's work on the cestodes did not attract the same attention as his work on trematodes. Steenstrup always insisted on the "nurse" nature of the cysticerci and other bladder-worms. Abildgaard (1790), as well as Creplin (1829 and 1839), had already furnished the information that certain sexless cestodes (*Schistocephalus* and *Ligula*) from the abdomen of fishes only become mature after their transference to the intestine of aquatic birds. These passive migrations were confirmed in an entire series of other cestodes, particularly by v. Siebold (1844, 1848, 1850) and E. J. van Beneden (1849), not by actual experiment, but by undoubted observation.

It was correctly believed that the ova or oncospheres penetrate into certain intermediate hosts, in which they develop into unsegmented larvæ. Here they remain until, with their host, they are swallowed by some predacious animal. They then reach the intestine, being freed from the surrounding membranes through the process of digestion, and settle themselves there to form the adult chain of proglottides. Though some few scientists, such as P. J. van Beneden and Em. Blanchard, deduced from these observations that the bladder-worms

(Cysticerci), which had hitherto been regarded as a separate class of helminthes, were only larval Tæniæ, this correct view was not at first universally accepted. The foundation was too slight, and van Beneden was of opinion that the Cysticerci were not necessary, but only appeared incidentally.

v. Siebold was a strenuous opponent to this theory, notwithstanding his experiences on the change of hosts of the Tetrarhynchus. Together with Dujardin (1850) he conjectured that the Tæniæ underwent a deviating cycle of development. He was of opinion that the six-hooked oncospheres left the intestine, in which the older generation lived, and were scattered about with the fæces, and finally re-entered *per os* (*i.e.*, with water and food) a host similar to the one they had left, in the intestine of which they were directly transformed into tapeworms. A change of host such as occurred in other cestodes was not supposed to take place (the history of the cestodes was at this time not entirely established). As the oncospheres of the Tænia are enveloped in one calcareous or several softer coverings which they cannot leave actively, and as, in consequence of this condition, innumerable oncospheres cannot penetrate into an animal, and others cannot reach the proper animal, v. Siebold conceded, at least for the latter, the possibility of a further development. But this was only supposed to occur because they had either invaded wrong hosts, or, having reached the right hosts, had penetrated organs unsuitable to their development, and had thus gone astray in their travels, and had become hydropically degenerated tæniæ. This was v. Siebold’s explanation of bladder-worms. Naturally, v. Siebold himself conjectured that a recovery of the diseased tapeworm might occur, in a few exceptional cases, after transmission into the correct host, as, for instance, in the *Cysticercus fasciolaris* of mice, the host of which is the domestic cat, and in which there is a seemingly normally developed piece of tapeworm situated between the caudal vesicle and the cysticercus head.

Guided by correct views, F. Küchenmeister undertook in Zittau the task of confirming the metamorphosis of *Cysticercus pisiformis* of hares and rabbits, into tapeworms in the intestine of the dog by means of feeding experiments. The first reports on the subject, published in 1851, were not likely to meet with universal approval, because Küchenmeister first diagnosed the actual tapeworm he had been rearing as *Tænia crassiceps*, afterwards as *Tænia serrata*, and finally as *Tænia pisiformis* n. sp. However, in any case, Küchenmeister, by means of the reintroduction of experimental investigation, rendered a great service to helminthology.

The publication of Küchenmeister's works induced v. Siebold to undertake similar experiments (1852 and 1853), which were partly published by his pupil Lewald in 1852. But the positive results obtained hardly changed Siebold's opinion, for although he no longer considered the bladder-worms as hydropically degenerated tapeworms, he still regarded them as tæniæ that had strayed. The change of opinion was partly due to an important work of the Prague zoologist, v. Stein (1853). He was able to examine the development of a small bladder-worm in the larvæ of the well-known meal-worm (*Tenebrio molitor*) and to demonstrate that, as Goeze had already proved in the case of *Cysticercus fasciolaris* of mice, first the caudal vesicle is formed and then the scolex, whereas Siebold believed that in bladder-worms the posterior end of the scolex was formed first, and that this posterior end underwent a secondary hydropic degeneration.

In opposition to v. Siebold, Küchenmeister successfully proved the necessity of the bladder-worm stage by rearing tapeworms in dogs from the *Cysticercus tenuicollis* of domestic mammals and from the *Cœnurus cerebralis* of sheep. He, and simultaneously several other investigators independently, succeeded, with material provided by Küchenmeister, in rearing the *Cœnurus cerebralis* in sheep from the oncospheres of the *Tænia cœnurus* of the dog (1854). R. Leuckart

obtained similar results in mice by feeding them with the mature proglottides of the *Tænia crassicollis* of cats (1854).

Küchenmeister also repeatedly reared the *Tænia solium* of man from the *Cysticercus cellulosæ* of pigs (1855), and from the embryos of this parasite P. J. van Beneden succeeded in obtaining the same *Cysticercus* in the pig (1854). As Küchenmeister distinguished the *Tænia mediocanellata*, known to Goeze as *Tænia saginata*, amongst the large tæniæ of man (1851), so it was not long before R. Leuckart (1862) succeeded in rearing the cysticercus of the hookless tapeworm in the ox. It is particularly to this last-named investigator that helminthology is indebted more than to any other author. He followed the gradual metamorphosis from oncospheres to cystic worms in all its details.

In view of all the researches that were made, and which are too numerous to mention individually, the idea that bladder-worms are abnormal or only incidental forms had to be abandoned. Everything pointed to the fact that in all cestodes the development is divided between two kinds of animals; in one—the host, the adult tapeworm is found; while in the other, the intermediate host, we find some form or other of an intermediate stage (cysticercus in the broadest sense). The practical application of this knowledge is self-evident. If no infected pork or beef is ingested, no tapeworm can be acquired, and also the rearing of cysticerci in the human body is prevented by avoiding the introduction of the eggs of tapeworms.

Though these results were definitely proved by numerous researches, yet they have been repeatedly challenged, notably by J. Knoch (1862) in Petrograd, who, on the basis of experiments, sought to confirm a direct development without an intermediate host and ciliated stage, at all events as regards *Dibothriocephalus latus*. However, the repeated communications of this author met with but little favour from competent persons, partly because the experiments were conducted very carelessly, and partly because their repetition

on dog and man (R. Leuckart) had no results (1863). It was only in 1883 that Braun was able to prove that the developmental cycle of *Dibothriocephalus latus* is similar to that of other Cestodes. The results obtained in other places by Parona, Grassi, Ijima and Zschokke render any discussion of Küchenmeister's conclusions unnecessary.[7] Long after Knoch, a French author, P. Mégnin, also pleaded for the direct development of some cestodes, and especially some tæniæ. He (1879) also sought to prove a genetic connection between the hookless and armed tapeworms of mammals, but the arguments he adduced, so far as they rest on observations, can be easily refuted or attributed to misinterpretation. Only one of these arguments is correct, namely, that the number of the species of tæniæ with which we are acquainted is far larger than that of the corresponding cystic forms; but this disparity alone cannot be taken as a proof of direct development. It can only be said that our knowledge in this respect is deficient. As a matter of fact, we have during recent years become acquainted with a large number of cystic forms, hitherto unknown, belonging to tæniæ which have long been familiar. It must also be borne in mind that no man in his lifetime can complete an examination for bladder-worms of the large number of insects, for instance, which may destroy an entire generation of an insectivorous species of bird within a small district.

Naturally it does not follow that direct development in the cestodes is altogether lacking. The researches of Grassi (1889) have furnished an example in *Hymenolepis* (*Tænia*) *murina*, which shows that development may sometimes take place without an intermediate host, notwithstanding the retention of the cystic stage. It was found that the oncospheres of this species, introduced into rats of a certain age, after a time grow into tapeworms without leaving the intestine, but not directly, for they bore into the intestinal wall, where they pass the cystic stage, the cysts afterwards falling into the intestinal lumen, where they develop into tapeworms. The recent experiments

of Nicoll (1911) show that the larval stages of *Hymenolepis murina* also occur in the rat-flea, *Ceratophyllus fasciatus*.

Important observations were soon made on the remaining groups of helminthes. The discussion on the origin of parasites soon became confined to the helminthes. Amongst the Nematoda, it had long been known that encapsuled forms existed that had at first been regarded as independent species, but very soon they were pronounced to be immature forms, in consequence of their lack of sexual organs. Though Dujardin and also v. Siebold regarded them as "strayed" animals, v. Stein (1853) very promptly demonstrated that the progeny of the nematodes were destined to travel by discovering a perforating organ in the larval nematodes of the mealworm. This was first experimentally confirmed (1860) by R. Leuckart, R. Virchow and Zenker, all of whom succeeded not only in bringing to maturity the muscle Trichinæ (known since 1830) in the intestine of the animals experimented upon, but were likewise able to follow the migrations of the progeny. Of course, the encapsulating brood remained in the same organism, and in this respect deviated from the broods of other helminthes which escape into the outer world and find their way into other animals, but the encapsuled nematodes could no longer be regarded as the result of straying. Subsequently, R. Leuckart worked out, more or less completely, the history of the development of numerous nematodes, or pointed out the way in which further investigations should be made. It has been found that in nematodes far more frequently than in other helminthes, the typical course of development is subject partly to curtailment and partly to complications, which sometimes considerably increase the difficulties of investigation and have hitherto prevented the attainment of a definite conclusion, though the way to it is now clear.

In a similar manner the works of R. Leuckart have cleared up the development of the *Acanthocephala* and *Linguatulida*. Of course,

much still remains to be done. So far, we do not even know all the helminthes of man and of the domestic animals in all their phases of life, and still less is known of those of other animals. We are indebted to the discoveries of the last fifty years for the knowledge arrived at, though comparatively few names are connected with it. The gross framework is revealed, but the gaps have only been filled up here and there. However, we may trustfully leave the completion of the whole to the future, without fear that any essential alterations will take place.

The deductions to be drawn are as follows: That the helminthes like the ectoparasites multiply by sexual processes, that the entire course of development of the helminthes is rarely or never gone through in the same host as is the case with several ectoparasites, that the progeny at an earlier or later stage of development, as eggs, embryos, or larvæ, quit the host inhabited by the older generation, and almost always attain the outer world: only in *Trichinella* does the development take place directly in the definite host. Where the eggs have not yet developed they go through the embryonic evolution in the outer world. The young larvæ are transmitted, either still enclosed within the egg or embryonic covering, to the intermediate host or more rarely they are transferred straight to the final host. In other cases they may hatch out from their envelopes, and after a longer or shorter period of free life, during which they may partake of food and grow, they, as before, penetrate, usually in an active way, into an intermediate host, or at once invade the final host. Exceptionally (*e.g.*, *Rhabdonema*), during the free life there may be a propagation of the parasitic generation, and in this case only the succeeding generation again becomes parasitic, and then at once reaches its final host. The young forms which have invaded the final host become mature in the latter, or after a longer or shorter period of parasitism again wander forth (as the Œstridæ, Ichneumonidæ, etc.), and reach the adult stage in the outer world. The young

stages, during which the parasites undergo metamorphoses or are even capable of producing one or several intermediate generations, are passed in the intermediate hosts until, as a rule, they are passively carried into the final host and there complete their cycle of development by the formation of the organs of generation. This mode of development, the spending of life in two different kinds of animals (intermediate and final host), is typical of the helminthes. This is manifested in the Acanthocephala, the Cestoda, the majority of the endoparasitic Trematoda, a number of the Nematoda, and the Linguatulidæ. There are now and then exceptions, however, in which, for instance, the host and intermediate host change order (*Trichinella*, *Hymenolepis murina*).

Parasites are hardly ever inherited amongst animals.[8] According to a few statements, however, *Trichinella* and *Cœnurus* are supposed to be transmissible from the infected mother to the fœtus. Otherwise most animals acquire their parasites, especially the Entozoa, from without, the parasites penetrating either actively, as in animals living in the water, or passively with food and drink. A particular predisposition to worms is not more likely than a spontaneous origin of parasites.

Derivation of Parasites.—Doubt now no longer exists as to the derivation of the temporary and of many of the stationary ectoparasites from free-living forms. This conclusion is founded on the circumstance that not only are there numerous intermediate degrees in the manner of living and feeding between predacious and parasitic animals, but that there is more or less uniformity in their structure. The differences that exist are easily explained as consequences of altered conditions of life. The case is more difficult in regard to groups that are exclusively parasitic (*Cestoda*, *Trematoda*, *Acanthocephala*, *Linguatulidæ*, and *Sporozoa*), or groups that are chiefly parasitic (*Nematoda*), because in these cases the gulf that divides these forms from free-living animals is wider. It is

true that we know that the nearest relatives of the *Linguatulidæ* are found amongst the *Arachnoidea*, and indeed in the *Acarina*; that, moreover, the structure and development of the *Sporozoa* refers them to the *Protozoa*, and allows some of them to be regarded as the descendants of the lowest *Rhizopoda*. We know that the *Trematoda*, and through these the *Cestoda*, are closely related to the *Turbellaria*, from which they may be traced. The *Nematoda*, and still more the *Acanthocephala*, stand apart. This is less evident, however, in the Nematoda, for there are numerous free-living members of these from which it is possible that the parasitic species may be descended. Indeed, this seems more than probable if such examples as *Leptodera*, *Rhabdonema* and *Strongyloides* are taken into consideration, as well as the conditions of life of free-living nematodes. These mostly, if not exclusively, spend their lives in places where decomposing organic substances are present in quantities; some species attain maturity only in such localities, and there propagate very rapidly. Should the favourable conditions for feeding be changed, the animals seek out other localities, or they remain in the larval form for some time until more favourable conditions set in. It is comprehensible that such forms are very likely to adopt a parasitic manner of life which at first is facultative (*Leptodera*, *Anguillula*), but may be regarded as the transition to true parasitism. The great advantages attached to a parasitic life consist not only in protection, but also in the supply of suitable food, and consequently in the easier and greater production of eggs, and thus fully account for the gradual passage of facultative parasitism into true parasitism. In many forms the young stages live free for some time (*Strongylidæ*), in others, as is the case in *Rhabdonema*, parasitic and free-living generations alternate; in others, again, the free period is limited to the egg stage or entirely suppressed.

Though it is possible thus to connect the parasitic with the free-living nematodes, by taking their manner of life into account, this matter

presents greater difficulties in regard to other helminthes. It is true that the segmented Cestoda may be connected with and traced from the less known and interesting single-jointed Cestoda (*Amphilina*, *Archigetes*, *Caryophyllæus*, *Gyrocotyle*). Trematodes are all parasites, with the exception of one group, *Temnocephalidæ*, several genera and species of which live on the surface of the bodies of Crustacea and turtles of tropical and sub-tropical freshwaters. *Temnocephalidæ* are, nevertheless, predacious. They feed on Infusoria, the larvæ of small insects and Crustacea. So far as is known they do not nourish themselves on part of the host. They belong to the group of commensals, or more correctly, to that of the SPACE PARASITES, which simply dwell with their host and do not even take a portion of the superfluity of its food. However, space parasitism may still be regarded as the first stage of commensalism, which is again to be regarded as a sort of transition to true parasitism.

It is possible that parasitism came about in this way in the trematodes, in which connection we must first consider the turbellaria-like ancestors of the trematodes. Much can be said in favour of such a genetic relationship between turbellaria and trematodes, and hardly anything against it. It should also be remembered that amongst the few parasitic turbellaria there are some that possess clinging discs or suctorial pores, and these are only differentiated from ectoparasitic trematodes by the possession of a ciliated integument, which is found only in the larval stages of the latter.

The Acanthocephala occupy an isolated position. Most authors certainly regard them as related to the nematodes; in any case, the connection is not a close one, and the far-reaching alterations which must have occurred prevent a clear view. Perhaps the free original forms of Acanthocephala are no longer in existence, but that such must have existed is a foregone conclusion.

An explanation of the CHANGE OF HOST so frequent in parasites is more difficult than that of their descent. R. Leuckart is of opinion that the present intermediate hosts, which belong principally to the lower animals, were the original hosts of the parasites, and fostered both their larval and adult stages. It was only in course of time that the original hosts sank to the position of intermediate hosts, the cause for this alteration being that the development of parasites, especially of the helminthes, through further development and differentiation extended over a larger number of stages. The earlier stages remained in their original hosts, but the later stages sought out other hosts (higher animals). To prove this, Leuckart points out that the mature stages of the helminthes, with but few exceptions, occur only in the vertebrates which appeared later in the development of the animal kingdom, while the great majority of intestinal worms of the lower animals only represent young stages, which require transmission into a vertebrate animal before they can become mature. The few helminthes that attain maturity in the lower animals (*Aspidogaster*, *Archigetes*) are therefore regarded by Leuckart as primitive forms, and he compares them with the developmental stages of helminthes, *Aspidogaster* with rediæ, *Archigetes* with cysticercoids. He classes the nematodes that become mature in the invertebrates with *Anguillulidæ*, *i.e.*, with saprophagous nematodes from which the parasitic species descend.

Leuckart therefore regards the change of hosts as secondary, so does Sabatier. The latter, however, adduces other reasons for this (lack of clinging organs and the necessity to develop them in an intermediary stage); but in this connection he only considers the Cestoda. In opposition to Leuckart, R. Moniez, however, is convinced that the migrations of the helminthes, as well as the system of intermediate hosts, represent the original order of things. Moniez traces all Entozoa from saprophytes, but only a few of these were able to settle directly in the intestine and there continue their

development. These are forms that at the present day still lack an intermediate host, such as *Trichocephalus*, *Ascaris*, and *Oxyuris*. In most other cases the embryos, however, consisted of such saprophytes as were, in other respects, suitable to become parasites, but were incapable of resisting the mechanical and chemical influences of the intestinal contents. They were therefore obliged to leave the intestine at once, and accomplished this by penetrating the intestinal walls and burrowing in the tissues of their carriers. In this position, assisted by the favourable conditions of nutrition, they could attain a relatively high degree of development. Mechanical reasons prevented a return to the intestines, where the eggs could be deposited. Most of them doubtless died off as parasites, as also their young stages do at present when they penetrate wrong hosts. Some of them, nevertheless, passively reached the intestine of beasts of prey. Many were destroyed in the process of mastication; for a small part, however, there was the chance of reaching the intestine of a beast of prey undamaged, and there, having become larger and more capable of resistance, maturity was attained. By means of this incidental coincidence of various favourable circumstances, these processes, according to Moniez, have been established by heredity and have become normal.

This is not the place to express an opinion either for or against the various hypotheses advanced, but the existence of these diametrically opposed views alone will show the great difficulty of the question. Independently, however, it appears more natural to come to the conclusion that parasitism, as well as change of hosts, were gradual transitions.

As a conclusion to this introductory chapter, a list of some of the most important works on the parasitology of man and animals is appended.

LITERATURE.

GOEZE, J. A. E. Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper. Blankenburg, 1782. 4to, 471 pp., with 44 plates.

ZEDER, J. G. H. Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer. von J. A. E. Goeze. Leipzig, 1800. 4to, with 6 tables.

RUDOLPHI, C. A. Entozoorum sive vermium intestinalium historia naturalis. I, Amstelod., 1808; ii, 1809. 8vo, with 18 plates.

RUDOLPHI, C. A. Entozoorum synopsis. Berol., 1819. 8vo, with 3 plates.

BREMSER, J. G. Ueber lebende Würmer im lebenden Menschen. Wien, 1819. 8vo, with 4 plates.

BREMSER, J. G. Icones helminthum, systema Rudolphii entozoologicum illustrantes. Viennae, 1824. Fol. (Paris, 1837).

DUJARDIN, F. Histoire naturelle des helminthes ou vers intestinaux. Paris, 1845. 8vo, with 12 plates.

DIESING, C. M. Systema helminthum. 2 vols. Vindobonnae, 1850, 1851. 8vo. Supplements by the same author: Revision der Myzhelminthen (Report of the Session of the Imp. Acad. of Science. Wien, xxxii, 1858); with addendum (ibid., xxxv, 1859); Revision der Cephalocotyleen (ibid., xlix, 1864, and xlviii, 1864); Revision der Nematoden (ibid., xlii, 1861); Supplements (ibid., xliii, 1862).

BENEDEN, P. J. VAN. Mémoire sur les Vers intestinaux. Paris, 1858. 4to, with 12 plates.

KÜCHENMEISTER, F. Die in und an dem Körper des lebenden Menschen vorkommenden Parasiten. Leipzig, 1855. 8vo, with 14 plates.

LEUCKART, R. Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten. I, Leipzig, 1863; II, Leipzig, 1876. 8vo.

COBBOLD, T. Sp. Entozoa; an Introduction to the Study of Helminthology. London, 1864. 8vo. Supplement, London, 1869.

DAVAINE, C. Traité des entozoaires et des maladies vermineuses de l'homme et des animaux domestiques. 2nd edit. Paris, 1877. 8vo.

LINSTOW, O. V. Compendium der Helminthologie, ein Verzeichniss der bekannten Helminthen, die frei oder in thierischen Körpern leben, geordnet nach ihren Wohnthieren, unter Angabe der Organe, in denen sie gefunden sind, und mit Beifügung der Litteraturquellen. Hanov., 1878. 8vo. Supplement, including the years 1878–1888, Hanov., 1888.

COBBOLD, T. Sp. Parasites; a Treatise on the Entozoa of Man and Animals, including some Account of the Entozoa. London, 1879. 8vo.

LEUCKART, R. Die Parasiten des Menschen und die von ihnen herrührenden Krankheiten. 2nd edit. Leipzig, 1879–1886. The Protozoa, Cestodes, Trematodes and Hirudinea have hitherto appeared (continued by Brandes).

BÜTSCHLI, O. Protozoa in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. i, Leipzig, 1880–1889. 8vo, with 79 plates.

BRAUN, M. Trematodes in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. iv, 1, Leipzig, 1879–1893. 8vo, with 33 tables. (The first thirteen sheets, comprising the history of the worms up to 1830, were compiled by H. Pagenstecher.)

ZÜRN, F. A. Die thierischen Parasiten auf und in dem Körper unserer Haussäugethiere, sowie die durch erstere veranlassten Krankheiten, deren Behandlung und Verhütung. 2nd edit. Weimar, 1882. 8vo, with 4 plates.

COBBOLD, T. Sp. Human Parasites; a Manual of Reference to all the Known Species of Entozoa and Ectozoa. London, 1882. 8vo.

KÜCHENMEISTER, F., and F. A. ZÜRN. Die Parasiten des Menschen. 2nd edit. Leipzig, 1888., 8vo, with 15 plates.

BLANCHARD, R. Traité de zoologie médicale. I, Paris, 1889; II, 1890. 8vo.

NEUMANN, L. G. Traité des maladies parasitaires non microbiennes des animaux domestiques. 2nd edit. Paris, 1892. 8vo. English edit., translated by G. Fleming. 2nd edit., revised by J. Macqueen. 1905. London: Baillière, Tindall and Cox.

LOOSS, A. Schmarotzerthum in der Thierwelt. Leipzig, 1892. 8vo.

RAILLIET, A. Traité de zoologie médicale et agricole. 2nd edit. I, Paris, 1895. 8vo.

PARONA, C. L'elmintologia italiana da' suoi primi tempi all' anno 1890. Genova, 1894. 8vo.

BRAUN, M. Cestoda in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. iv, 2, Leipzig, 1894–1900. 8vo, with 24 plates.

MOSLER, F., and E. PEIPER. Thier Parasit. (Spec. Path. u. Ther. v. H. Nothnagel. Vol. vi.) Wien, 1894. 8vo, with 124 illustrations.

LAVERAN, A., et R. BLANCHARD. Les hématozoaires de l'homme et des anim. Paris, 1895. 12mo, with 30 figs.

SLUITER, C. R. De dierl. paras. v. d. mensch en van onze huisdier. Haag, 1895. 8vo.

BLANCHARD, R. Malad. parasit., paras. animaux, paras. végét. à l'exclus. des bacter. (Traité de pathol. gén. de Ch. Bouchard, vol. ii.) Paris, 1895. 8vo, with 70 figs.

HUBER, J. CH. Bibliographie der klin. Helminthol. München, 1895. 8vo. With Supplement, 1898, and continued as Bibl. d. klin. Entomol. München, 1899–1900.

MONIEZ, R. Traité de parasitol. anim. et veget. appl. à la médecine. Paris, 1896. 8vo, with 116 figs.

WEICHSELBAUM. Parasitologie (Weil's Handb. d. Hyg.). Jena, 1898. 8vo, with 78 illustrations.

KRAEMER, A. Die thierischen Schmarotzer des Auges (Gräfe and Sämische's Handb. d. ges Augenheilk.). Leipzig, 1899. 8vo, with 16 illustrations.

CHOLODKOWSKY, N. A. Icones helm. hominis. St. Petersburg, 1898–99. Fol. (atlas with 15 plates).

PERRONCITO, E. I parassiti dell' uomo e degli animali utili e le più comuni malattie da essi prodotti. II_{a} ed. Milano 1902. 8o. con 276 fig. e 25 tav.

STILES, Ch. W. and A. HASSALL. Index Catalogue of Medicine and Veterinary Zoology. Washington, 1902 (U.S. Dept. of Agric., Bur. of Anim. Ind., Bull. No. 39).

NEVEU-LEMAIRE, M. Précis de parasitologie humaine, parasites végétaux et animaux. 4e édit. Paris, 1911.

HOFER, B. Handbuch der Fischkrankheiten. München, 1904. 8o. 18 Taf. 222 Abb.

GUIART, J., and L. GRIMBERT. Précis de Diagnostic chimique, microscopique et parasitologique. Paris, 1906. With 500 figs.

OSTERTAG, R. Handbuch der Fleischbeschau. V. Aufl. mit 265 Abb. Stuttgart, 1904.

STILES, Ch. W. The International Code of Zoological Nomenclature as applied to Medicine (Hygienic Lab., Bull. No. 24, Washington, 1905).

STILES, C. W., and HASSALL, A. Trematoda and Trematode Diseases. (Index Catalogue of Med. and Vet. Zoology.) Hygienic Lab., Bull. No. 37, Washington, 1908.

STILES, C. W., and HASSALL, A. Cestoda and Cestodaria. Hygienic Lab., Bull. No. 85, Washington, 1912.

LALOY, L. Parasitisme et mutualisme dans la nature. Paris, 1906. 8vo, 284 pp., 82 figs.

THEOBALD, F. V. A Monograph of the Culicidæ of the World. 5 vols. and plates. 1901–1910. London: Brit. Museum, Nat. Hist.

JAMES, S. P., and LISTON, W. G. The Anopheline Mosquitoes of India. 2nd edit. 1911. Calcutta: Thacker, Spink and Co.

HOWARD, L. O., DYAR, H. G., and KNAB, F. The Mosquitoes of North and Central America and the West Indies. 2 vols. 1912. Washington: Carnegie Institution.

AUSTEN, E. E. African Blood-sucking Flies. 1909. London: Brit. Museum, Nat. History.

AUSTEN, E. E. A Handbook of Tsetse-flies. 1911. London: Brit. Museum, Nat. History.

CASTELLANI, A., and CHALMERS, A. J. Manual of Tropical Medicine. 2nd edit. 1,747 pp. 1913. London: Baillière, Tindall and Cox.

KOLLE and WASSERMANN. Handbuch der pathogenen mikroorganismen. Jena: Gustav Fischer.

MINCHIN, E. A. An Introduction to the Study of the Protozoa. 1912. London: Arnold.

LAVERAN, A., et MESNIL, F. Trypanosomes et Trypanosomiases. 2nd edit. 1912. Paris: Masson and Co.

DOFLEIN, F. Lehrbuch der Protozoenkunde. 3rd edit. 1911. Jena: Gustav Fischer.

NUTTALL, G. H. F., WARBURTON, C., COOPER, W. F., and ROBINSON, L. E. Ticks—a Monograph of the Ixodoidea. Pt. I (1908). Pt. II. (1911). University Press, Cambridge, England.

BRUMPT, E. Précis de Parasitologie. 2nd edit. 1913. Paris: Masson and Co.

PATTON, W. S., and CRAGG, F. W. A Text-book of Medical Entomology. 1913. Christian Literature Society of India: London, Madras, and Calcutta.

JOURNALS.

For current researches the following, among others, should be consulted:—

Annals of Tropical Medicine and Parasitology, Liverpool.

Annales de l'Institut Pasteur, Paris.

Archives de Parasitologie, Paris.

Archives de Zoologie Expérimentale et Générale, Paris.

Archiv für Protistenkunde, Jena.

Archiv für Schiffs- und Tropen-Hygiene, Leipzig.

Bulletin of Entomological Research, London.

Bulletin de l'Institut Pasteur, Paris.

Bulletin de la Société de Pathologie Exotique, Paris.

Bulletins of the Bureau of Animal Industry, Washington.

Centralblatt für Bakteriologie und Parasitenkunde, Jena.

Compt. Rend. Acad. Sci., Paris.

Compt. Rend. Soc. Biol., Paris.

Indian Journal of Medical Research, Calcutta.

Journal of Experimental Medicine, New York.

Journal of Medical Research, Boston.

Memorias do Instituto Oswaldo Cruz, Rio de Janeiro.

Parasitology, Cambridge.

Proceedings of the Royal Society, London.

Quarterly Journal of Microscopical Science, London.

Review of Applied Entomology, London.

Tropical Diseases Bulletin (London: Tropical Diseases Bureau).

Zeitschrift für Infektionskrankheiten, Berlin.

THE ANIMAL PARASITES OF MAN.

Man is one of those organisms in on on which a whole host of parasites find conditions suitable for their existence: Protozoa, Platyhelminthes, Nematoda, Acanthocephala, Hirudinea, and a large number of Arthropoda (Arachnida as well as Insects) all include members which are parasites of man. These animals either live on the external surface of the body or within the intestine and its appendages. Other organs and systems are not quite free from foreign organisms—we are acquainted with parasites in the skeletal system, in the circulatory system, in the brain, in the muscles, in the excretory and genital organs, and even in the organs of sense.

It is possible, and perhaps might be advantageous, to arrange and describe the parasites of man according to the situations in which they are found (parasites of the skin, intestinal parasites, etc.). Their description in the various stages of development would, however, be disturbed when, as is generally the case, the different stages are passed in different organs, and a work which treats more fully of the natural history of the parasites than of the local disorders to which they give rise would suffer thereby. It is, therefore, preferable to describe the parasites of man in their systematic order, and to mention their different situations in man in describing each species.

A. **PROTOZOA**,

BY

H. B. FANTHAM, M.A., D.Sc.

All those animal organisms which throughout their entire life never rise above the unicellular stage, or merely form simple, loose colonies of similar unicellular animals, are grouped under the term *Protozoa* (Goldfuss, 1820), as the simplest types of animal life. All the vital functions of these, the lowest forms of animals, are carried out by their body substance, the protoplasm (sarcode). Often particular parts possess special functions, but the limits of a cell are never over-stepped

thereby. These special parts of the cell are called "cell-organs"; recently they have been termed "organellæ."

The living protoplasm has the appearance of a finely granular, viscid substance which, as a rule, when not surrounded by dense investing membranes or skeletons, exhibits a distinct kind of movement, which has been termed amœboid. According to the species, processes of different forms and varying numbers called pseudopodia are protruded and withdrawn, and with their assistance these tiny organisms glide along—it might almost be said flow along—over the surface. In most Protozoa two layers of cytoplasm may be recognised, and distinguished by their appearance and structure, namely, the superficially situated, viscid, and quite hyaline ectosarc or ectoplasm, and the more fluid and always granular endosarc or endoplasm, which is entirely enveloped by the ectoplasm. The two layers have different functions; the movements originate from the ectoplasm, which also undoubtedly fulfils the functions of breathing, introduction of food and excretion. The endoplasm, which in some forms (Radiolaria) is separated from the ectoplasm by a membrane, undertakes the digestion of the food. To this distribution of functions between the various layers of cytoplasm is due the development of particular cellular organs, such as the appearance of cilia, flagella, suctorial tubules (in the Suctoria) and the myophan striations, which are contractile parts of the ectoplasm in Infusoria and Gregarines. In many cases (Flagellata, Ciliata), an area is differentiated for the ingestion of food (oral part, cytostome) to which there is often added a straight or curved opening (cytopharynx), through which the food reaches the endoplasm. The indigestible residue is either cast off through the oral part or excreted by a special anal part (cytopyge). In rare cases, structures sensitive to light, the so-called pigment or eye spots are developed, *e.g.*, *Euglena*. In the case of Infusoria the endoplasm circulates slowly, and agglomerations of fluids (food vacuoles) sometimes appear around each bolus of food; in these vacuoles the food is digested under the action of certain materials (ferments). Even in the lowliest Protozoa fluids to be excreted are, as a rule, gathered into one, or, more rarely, several contractile vacuoles, which regularly discharge their contents. This action, however, is to a certain extent governed by the temperature of the surrounding medium. In some Infusoria a tube-like channel in the cytoplasm is joined to the contractile vacuole which usually occupies a certain position; this forms a sort of excretory duct, and there are also supply-canals leading to these organellæ.

Very frequently various substances are deposited in the endoplasm, such as fatty granules, drops of oil, pigment granules, bubbles of gas or crystals. More solid skeletal substances are secreted in or on the ectoplasm. To the latter belong the cuticle of the Sporozoa and Infusoria, the chalky shells containing one or several